Climate Matching of Host Species and Potential Microbial Control Agents

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Climate Matching: a tool for planning exploration for entomopathogens of insect and mite pests

- Foreign exploration for natural enemies in the putative center of origin of invasive species

- Domestic exploration for entomopathogens

- A method to increase the probability of successful introductions and in some cases establishment of entomopathogens

Climate Matching Variables

- annual values of extreme minimum temperature
- extreme maximum temperature
- annual number of frost free days
- annual degree days
- annual precipitation
- annual Potential Evapotraspiration (PET)
- average temperature of the 3 warmest months of the year
- PET for the 3 warmest months of the year
- precipitation for the 3 warmest months of the year

Tools for obtaining climate information in regions where the target insect is found

- Historical climate records
- Reports and publications from colleagues
- Climate software (Climex, PC Climate, NAPPFAST)
- Serendipity

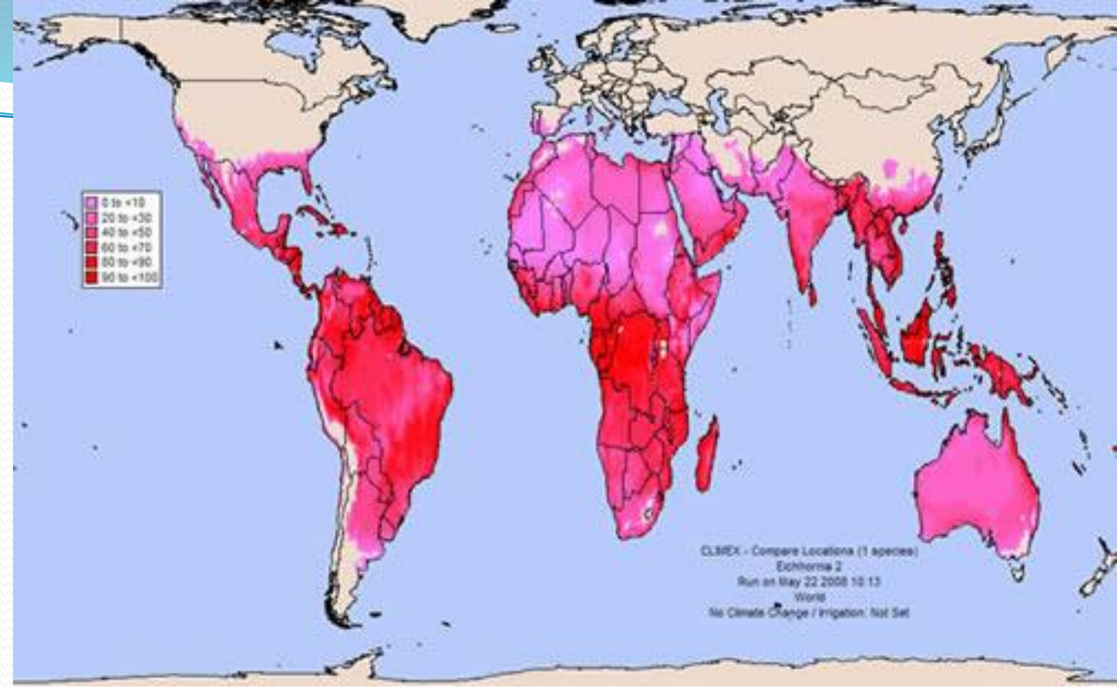
Climex comparison of locations and years

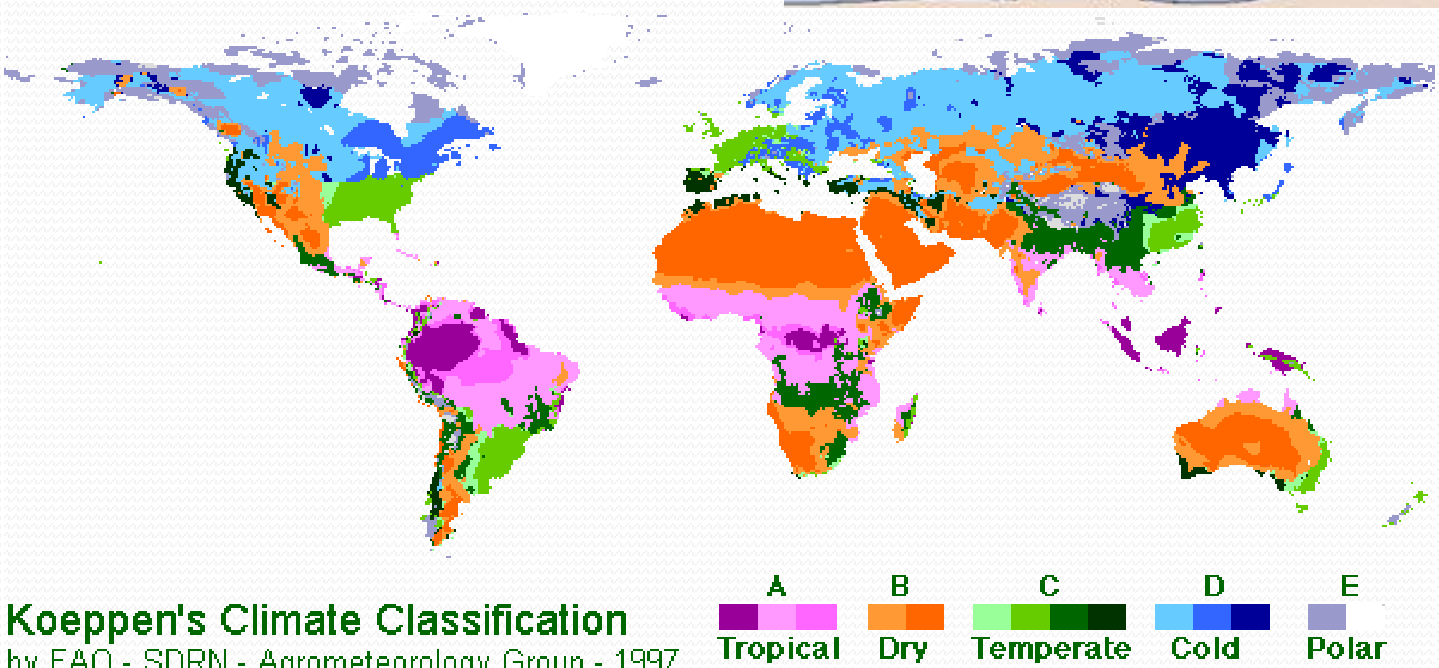
- Uses minimal data sets and simple functions to describe the species' response to temperature and moisture, using Compare Locations or Compare Years options.
- Growth Index describes the potential for growth of a population during the favorable season, and four stress indices (Cold, Hot, Wet and Dry).
- Stress Index describes the probability of surviving unfavorable seasons.
- Growth and Stress Indices are combined to give an overall measure of favorableness of the location or year for a species, Ecoclimatic Index.

Climex climate matching function

- CLIMEX includes a climate-matching function that can be used in the absence of any knowledge of the distribution of a species
- The Match Climates option allows the user to directly compare the temperature, rainfall, rainfall pattern and relative humidity of a given location with any number of other locations
- It provides a method of identifying sites with similar climates for targeting collection and release sites, or for assessing risks from exotic species
- Weighting and masking functions allow the user to select variables for modeling (e.g., temperature) or to choose particular months that need to be used in a comparison (e.g., summer months in temperate zones).

Climex determined correspondence of climate among tropical and subtropical locations →

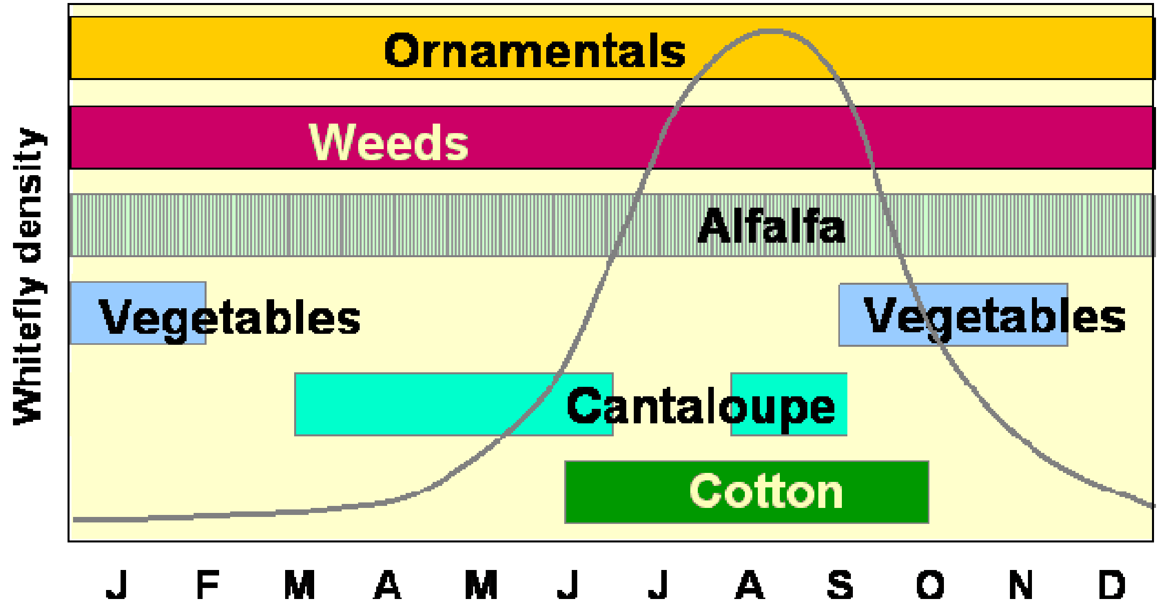




Selection of collection sites – it may not always be the putative center of origin of the targeted pest

- Do the climates in the collection sites match that of the release sites?
- Is the pest species there?
- Are related species there?
- Is it a really cool place?

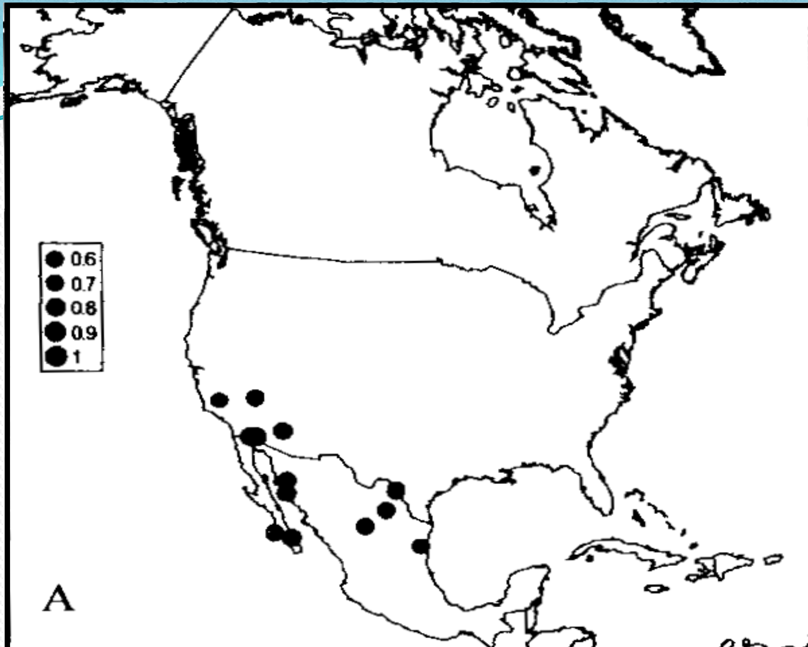
Bemisia tabaci adult and nymphs infected with *Isaria fumosorosea*



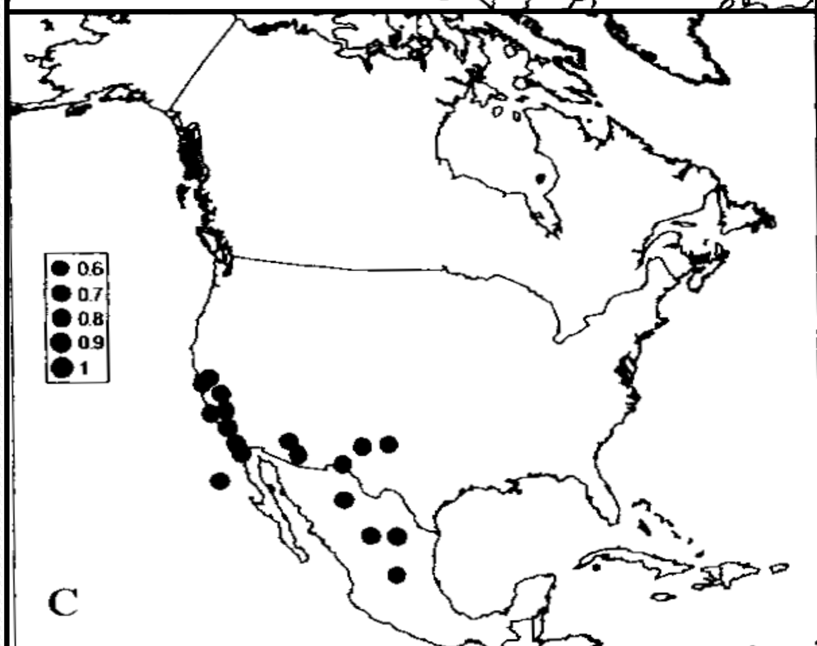
Foreign locations in which collections of natural enemies of *Bemisia tabaci* were made

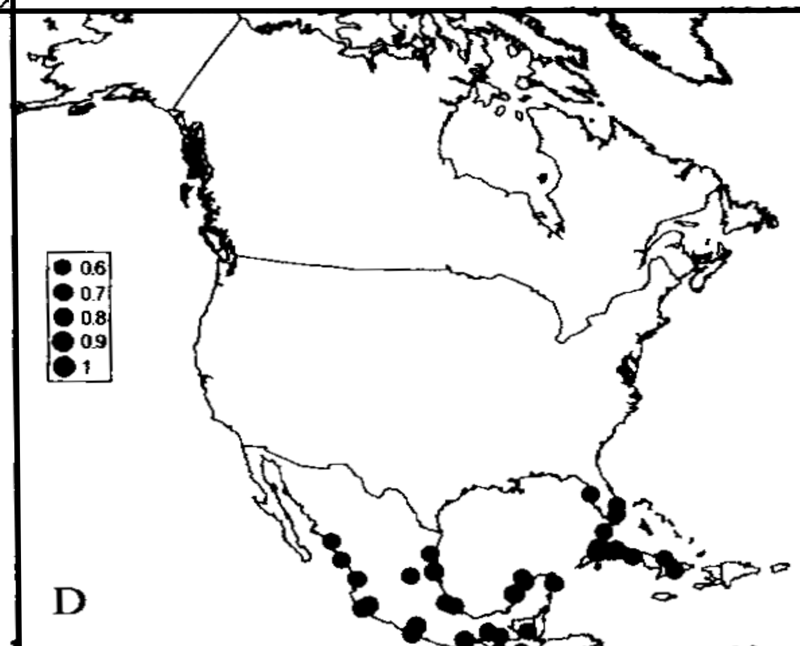
- ❖Mediterranean countries – Spain, France, Italy, Greece, Crete
- ❖Middle East – Israel, Egypt
- ❖Africa – Ethiopia
- ❖Western Asia – Pakistan, India, Nepal
- ❖East Asia – Taiwan
- ❖Southeast Asia – Thailand, Malaysia, Philippines
- ❖South America – Brazil, Argentina

Kirk et al. 1993, 2000, 2008, Lacey et al. 1993, 2008, Legaspi et al. 1996

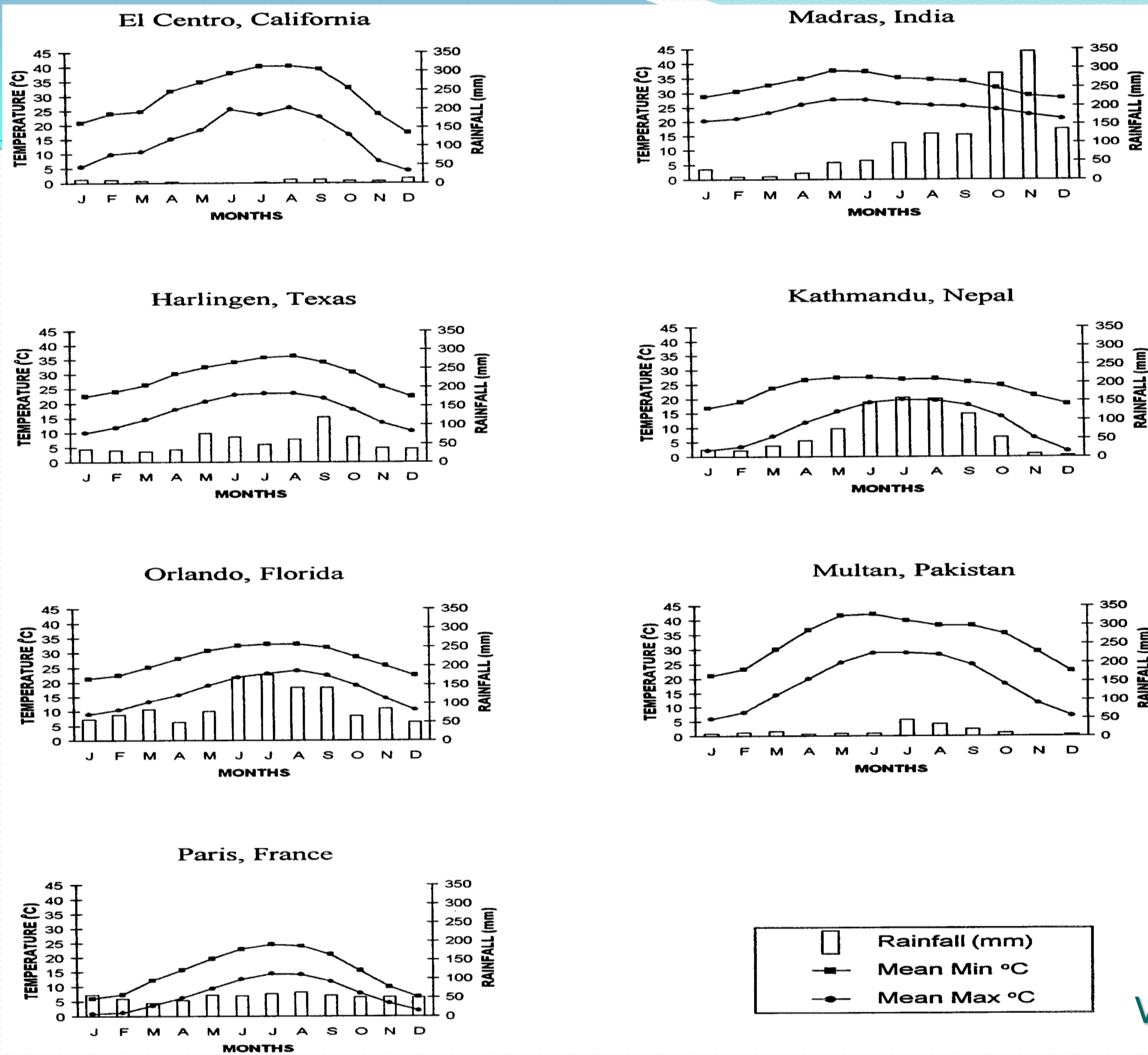


CLIMEX determined locations in the USA and Mexico that correspond to those in A. Pakistan, C. Spain D. Thailand





Kirk et al. 2008



Vidal et al. 1997

Isaria fumosorosea isolates from temperate and tropical countries

European Isolates
Pfr INRA 04 *Mamestra brassicae* (Lep.: Noctuidae) Ile-de-France/France
Pfr INRA 13 *Lycophotia* sp. (Lep.: Noctuidae) Provence/France
Pfr INRA 56 *Adelphocoris* sp. (Hem.: Miridae) Italy

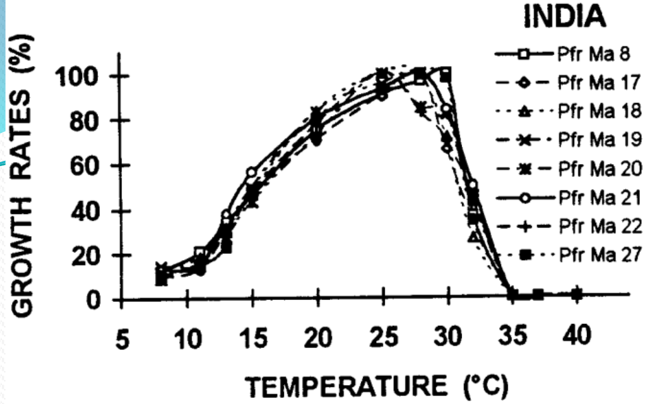
India
Pfr Ma 8*c* (ARSEF 4490) *B. tabaci* (Hom.: Aleyrodidae) Madras/India

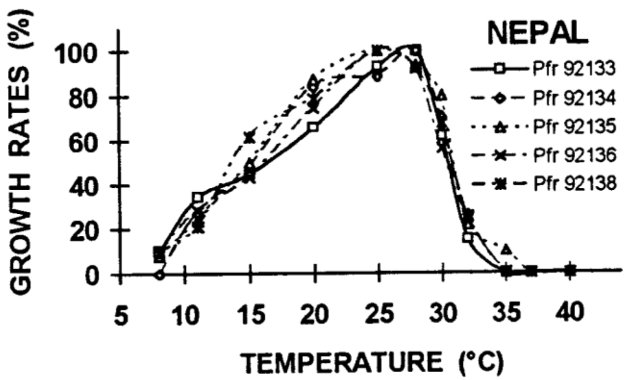
Nepal
Pfr 92133*c* (ARSEF 4482) *B. tabaci* (Hom.: Aleyrodidae) Kathmandu/Nepal

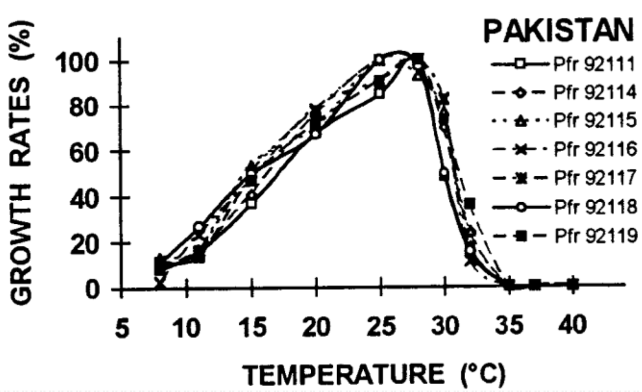
Pakistan
Pfr 92111*c* (ARSEF 4498) *B. tabaci* (Hom.: Aleyrodidae) Multan/Pakistan

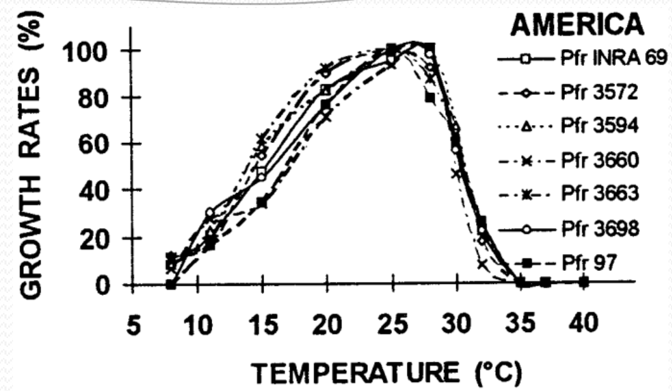
USA
Pfr 97, *B. tabaci,* Apopka, FL, several Pfr isolates, *B. tabaci*, Texas and California Imperial Valley, CA

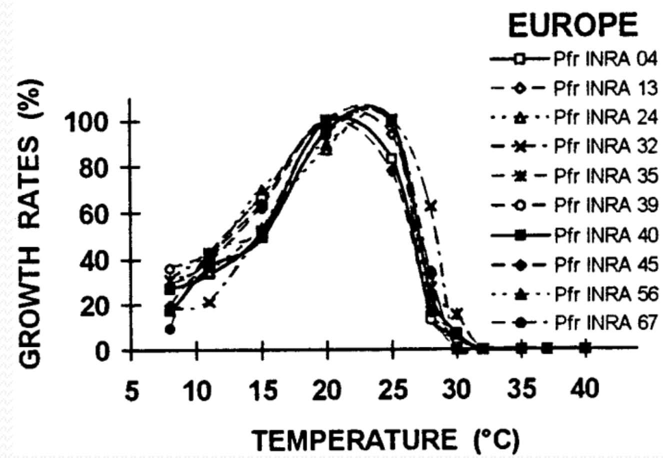
Vidal et al. 1997



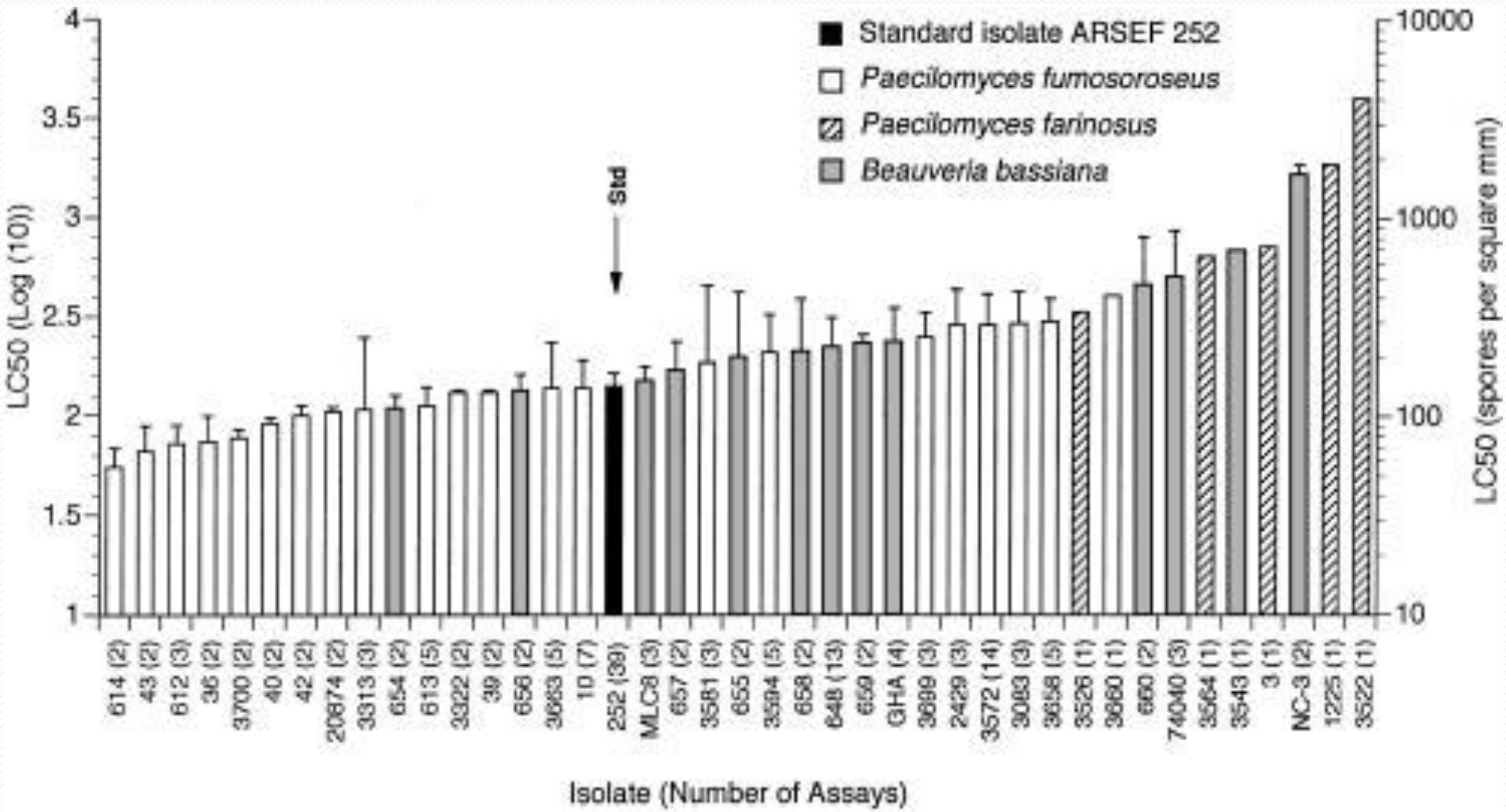






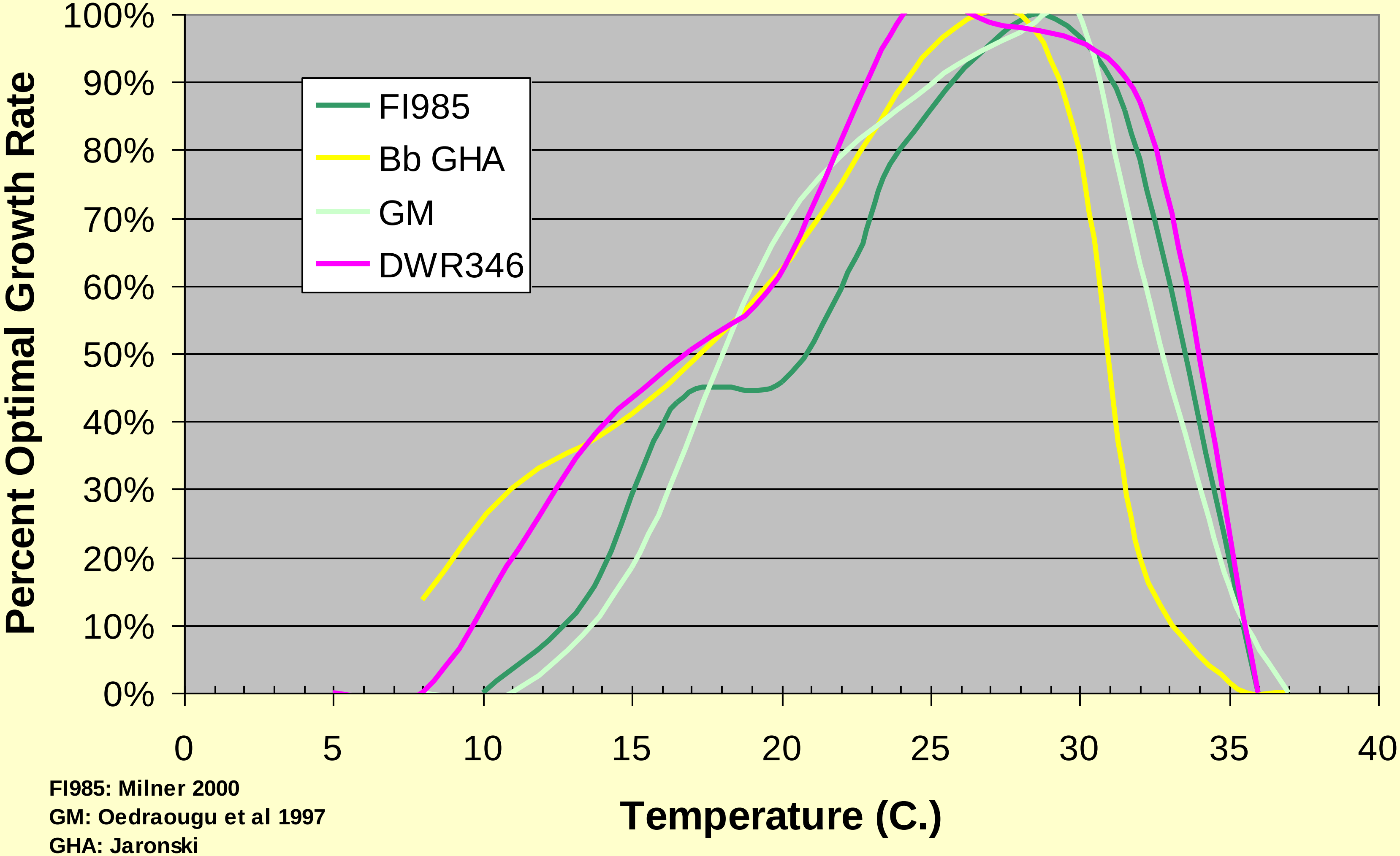


Comparative growth rates of *Isaria fumosorosea* from Western Asia, SW & SE US and France, Vidal et al. 1997

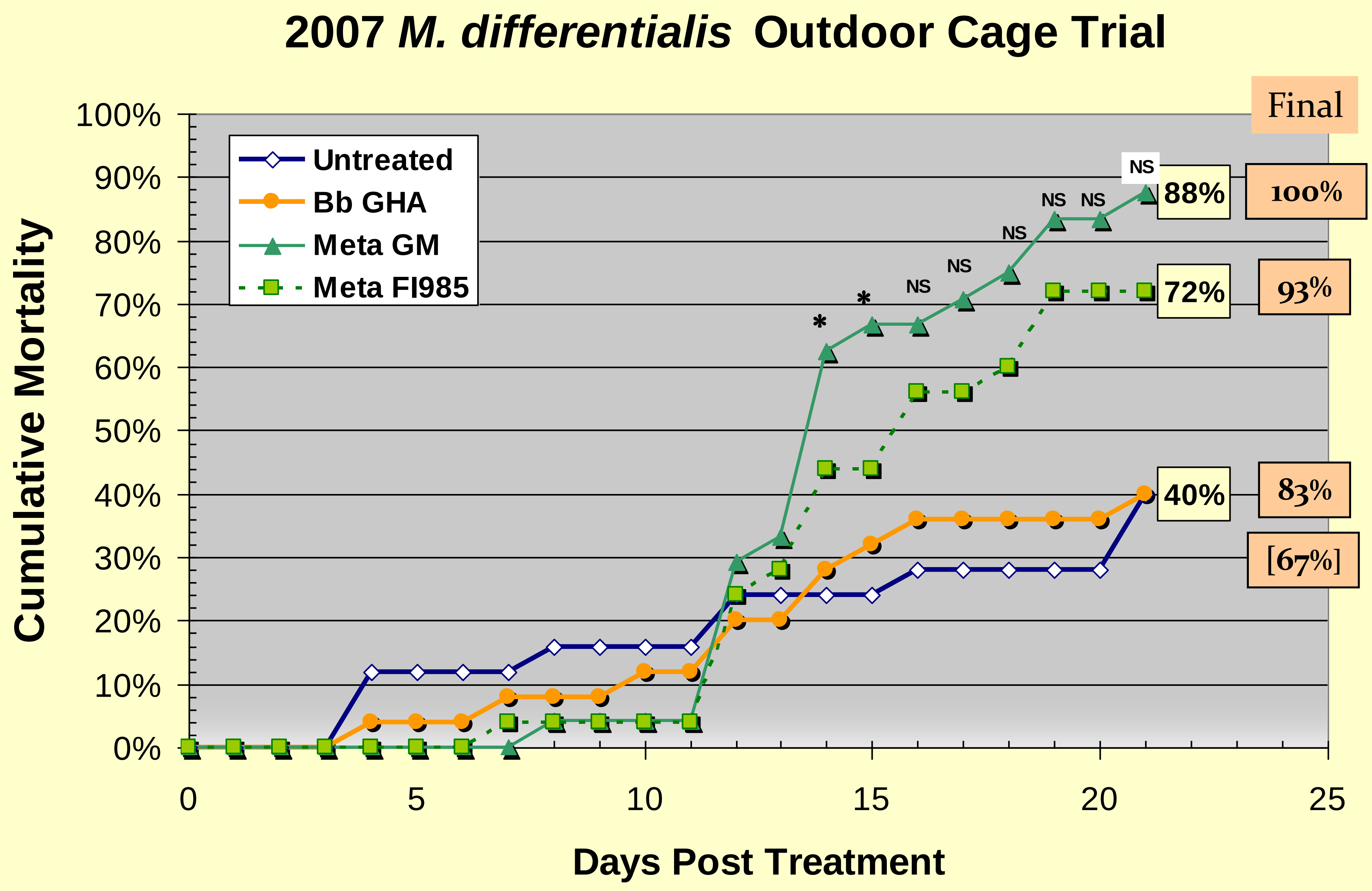


Wraight et al. 1998

Thermal Tolerances of Bb GHA, Meta FI-985, Meta Green Muscle (GM)



FI985: Milner 2000
GM: Oedraougu et al 1997
GHA: Jaronski

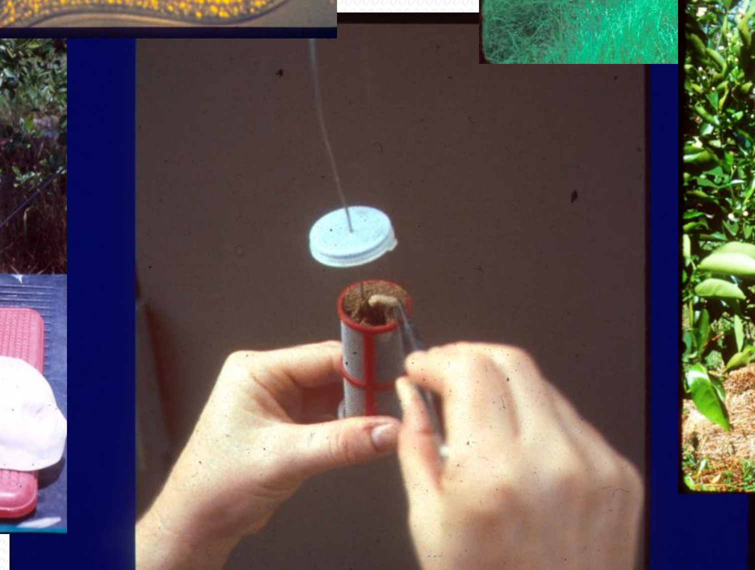


2007 *M. differentialis* Outdoor Cage Trial
Final
Untreated
Bb GHA
Meta GM
Meta FI985
Cumulative Mortality
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5
10
15
20
25
Days Post Treatment
*
*
NS
NS
NS
NS
NS
NS
88%
100%
72%
93%
40%
83%
[67%]

Diaprepes abbreviatus
"The Evil Weevil"

- Native to the Caribbean
- First detected in Florida in 1964
- Spread throughout Florida; recently detected in Texas, California, The Mall of America, and the UK.
- Highly polyphagus: citrus, ornamentals, other crops
- Larvae feed on roots, girdle trees, facilitate infection by plant pathogens (*Phytophthora spp*.)

Applying Entomopathogenic Nematodes to Control *D. abbreviatus* Larvae



Limiting factors

- Temperature Ranges
  - *S. carpocapsae* 20-25ºC -fair at 15ºC
  - *S. feltiae* 15-25ºC (moderate to good at 10ºC)
  - *S. riobrave* 20-32ºC, optimum 27ºC
- Moisture
  - *S. carpocapsae* damp for 8-24 hours
  - *S. feltiae* similar to *S. carpocapsae*, but may require less time to find host insect

Effect of mulch on EPN activity against CM

Examples of long term establishment

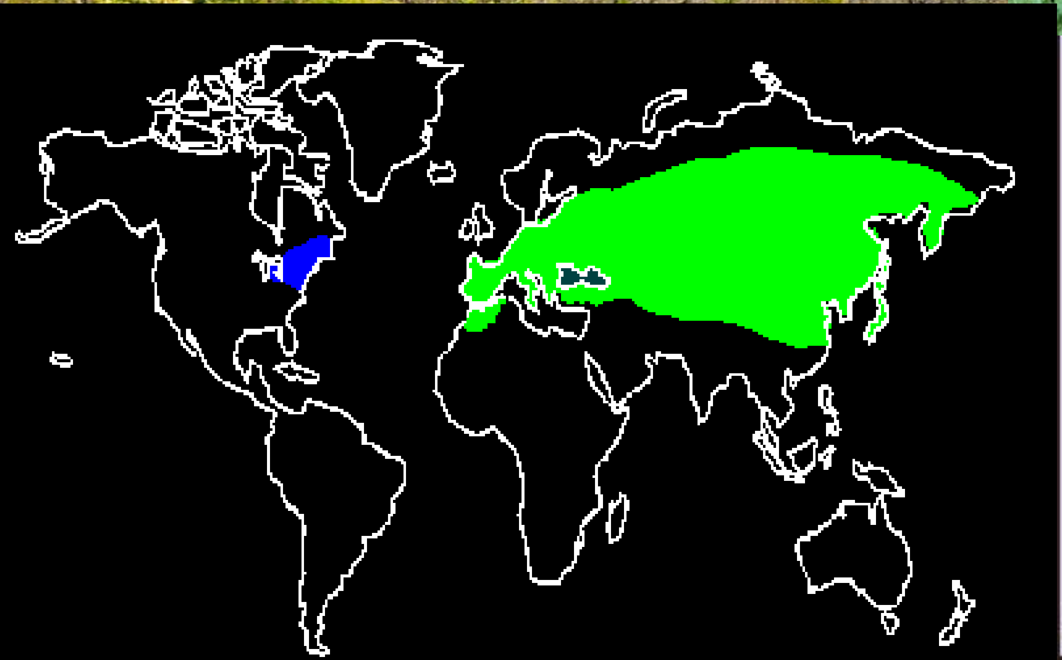
- *Entomophaga maimaiga*, gypsy moth, Japan to NE USA, 1983-85 by Soper et al. Several releases but no immediate signs of being established, but then rediscovered in NE in 1990 by (Andreatis and Weseloh.) Established and spreading – with a little help from its friends

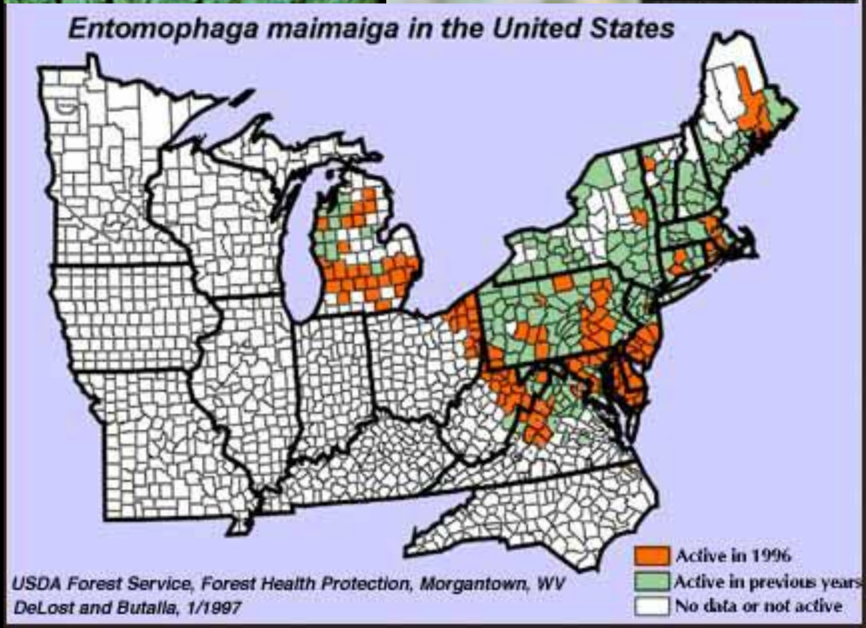
- *Steinernema scapterisci,* mole cricket, Uruguay to FL, USA, host and climate based explorations. Well established (Smart Parkman)

- *Zoophthora radicans*, spotted alfalfa, Israel to Australia. Host and climate based exploration. Established.

- *Deladenus siricidicola, Sirex noctilio*, Hungary and New Zealand to Australia, Australia to S. Africa & Brazil, Brazil to Argentina, New Zealand to Uruguay. Established in Australia and other countries.

Importation of *Entomophaga maimaiga* for control of gypsy moth





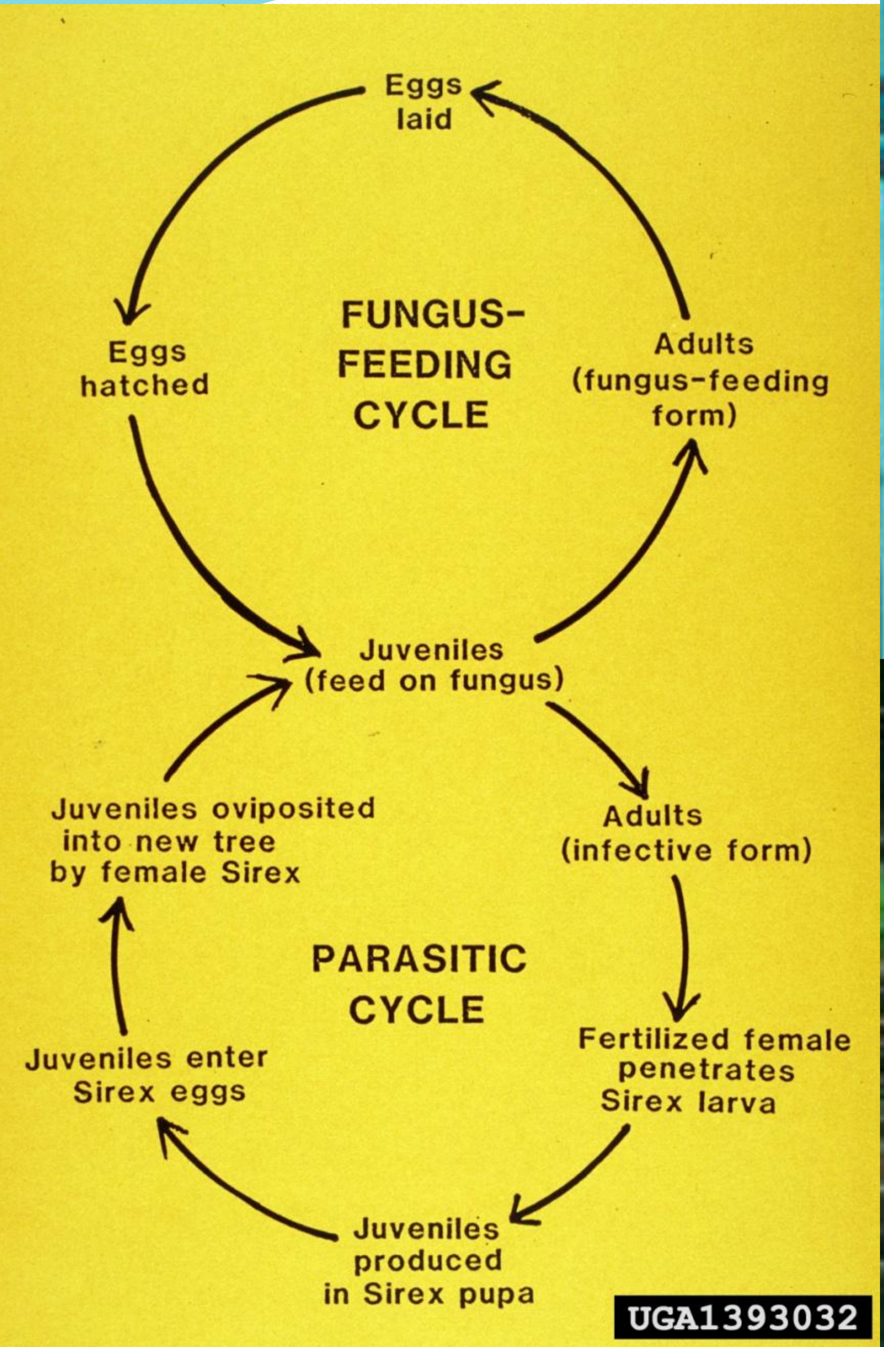
Classical Biological Control using an Entompathogenic Nematode

- Mole crickets introduced into Florida
- *Steinernema scapterisci* collected in Uruguay

Deladenus siricidicola (Neotylenchidae) a classical biological control agent of *Sirex noctilio*

Amylostereum areolatum-killed Monterrey pines

Deladenus siricidicola



Other examples

- *Ashcersonia* spp. from several countries with similar climate to release sites in Azerbaijan and Georgia established on citrus whitefly
- *Lecanicillium lecanii*, from India and Sri Lanka to the Seychelles
- *Coelomomyces stegomyiae*, from Singapore to Tokelau
- Granulovirus of *H. brillians*, from AZ and Mexico to CA
- *Lagenideum gigantium*, from Carolina to CA
- *Romanomermis culicivorax*, LA USA to Tokelau Islands; and USA to USA, several sites
- *S. riobrave* from soil in Texas to *Diaprepes abbreviatus* in FL and weevils in other locations
- MNPV from *A. gemmatalis*, Brazil to LA USA

Conclusions

- Knowledge of climate and other host factors has been a component of efficiently directed foreign exploration and successful establishment of some entomopathogens and nematodes

- Some entomopathogenic fungi, especially Hypocreales, are not necessarily superior to native fungi collected from habitats in which the invasive species has become established

- Implementation of “exotic” entomopathogens is often hindered or not permitted at all

Climate matching for "safe" fungi